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REDD Methodological Module

"Estimation of carbon stocks and changes in carbon stocks in the wood products pool"

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I. SCOPE, APPLICABILITY AND PARAMETERS

Scope

This module allows for estimating carbon stocks and changes in carbon stocks in the wood products pool.

Applicability

This module applies in all cases where wood is harvested and converted to wood products.

Parameters

This module produces the following parameters:

Parameter	SI Unit	Description
C_{WP} and ΔC_{WP}	t CO_2-e	Total carbon stock and total carbon stock change in wood products pool (equivalent)
ΔC_{G_WP}	t C yr^{-1}	Increase in (input to) carbon stock in wood products pool

II. PROCEDURES

Estimation of carbon stock change in the wood products pool

Total carbon stock change in wood products is estimated as:

$$\Delta C_{WP} = \sum_{t=1}^{t} \Delta C_{WPt} \qquad (1)$$

Where:

ΔC_{WP} Carbon stock changes in wood products; t CO_2-e

ΔC_{WPt} Annual carbon stock change in wood products at time t; t CO_2-e yr^{-1}

t	1, 2, 3, … *t* years elapsed since the start of the project activity

Note that because stock change is equivalent to inputs (below), total carbon *stock change* in the wood products pool is synonymous with total carbon *stock* in the wood products pool.

Change in carbon stocks in wood products

Carbon stock changes are estimated using the gain-loss method, in which only the proportion of extracted stocks estimated to remain sequestered after 100 years is included as gain. No losses (due to wood waste and eventual oxidation of retired wood products) are included as they are implicitly incorporated in the estimation of stocks remaining sequestered after 100 years (Equation 4).

$$\Delta C_{WPt} = \Delta C_{G\_WPt} * \frac{44}{12} \quad (2)$$

Where:

$\Delta C_{WP,t}$	Annual net carbon stock change in wood products at time *t*; t CO_2-e yr^{-1}
ΔC_{G_WPt}	Increase in carbon stock in wood products at time t; t C yr^{-1}
t	*1, 2, 3* … *t* years elapsed since the start of the project activity
44/12	Ratio of molecular weight of CO_2 to carbon, t CO_2-e t C^{-1}

This module estimates annual increase in (inputs to) carbon stock in wood products at time *t* (ΔC_{G_WPt}) following the conceptual framework detailed in Winjum *et al.* 1998[1].

Step 1: Calculate the biomass carbon of the volume extracted by wood product type *ty* at time *t* from within the project boundary:

$$C_{XB,ty,t} = \sum_{j=1}^{S_{PS}} (V_{ex,ty,j,t} * D_j * CF_j) \quad (3)$$

Where:

$C_{XB,ty,t}$	Total stock of extracted biomass carbon from within the project boundary by class of wood product *ty* at time *t*; t C

[1] Winjum, J.K., Brown, S. and Schlamadinger, B. 1998. Forest harvests and wood products: sources and sinks of atmospheric carbon dioxide. *Forest Science* 44: 272-284

Note: other available references/studies were either not broadly applicable or required more parameters than are likely to be available in a developing country context. Key parameters may be updated as new empirically-based findings become available.

$V_{ex,ty,j,t}$	Volume of timber extracted from within the project boundary (does not include slash left onsite) by species *j* and wood product class *ty* at time *t*; m^3
D_j	Mean wood density of species *j*; t d.m.m^{-3}
CFj	Carbon fraction of biomass for tree species *j*; t C t^{-1} d.m.
t	*1, 2, 3 … t* years elapsed since the start of the project activity
j	*1, 2, 3 … S* tree species
ty	Wood product class – defined here as sawnwood, wood-based panels, other industrial roundwood, paper and paper board, and other

Step 2: Calculate the proportion of biomass carbon extracted at time *t* that remains sequestered in long-term wood products after 100 years. This module applies the simplifying (and conservative) assumption that all extracted biomass not retained in long-term wood products after 100 years is emitted in the year harvested, instead of tracking annual emissions through retirement, burning and decomposition. All factors are derived from Winjum *et al*. 1998.

$$\Delta C_{G\_WP,t} = \sum_{s,w,oir,p,o}^{ty} \left(\left(\left(C_{XB,ty,t} - WW \right) - SLF \right) - OF \right) \quad (4)$$

Where:

ΔC_{G_WPt}	Increase in carbon stock in wood products at time t; t C yr^{-1}
$C_{XB,ty,t}$	Total stock of extracted biomass carbon from within the project boundary by class of wood product *ty* at time *t*; t C
WW	Wood waste. The fraction immediately emitted through mill inefficiency; t C t C^{-1}
SLF	Fraction of wood products that will be emitted to the atmosphere within 5 years of timber harvest; t C t C^{-1}
OF	Fraction of wood products that will be emitted to the atmosphere between 5 and 100 years of timber harvest; t C t C^{-1}
ty	Wood product class – defined here as sawnwood, wood-based panels, other industrial roundwood, paper and paper board, and other
t	*1, 2, 3 … t* years elapsed since the start of the project activity

Wood waste fraction (WW):

Winjum *et al*. 1998 indicate that the proportion of extracted biomass that is oxidized (burning or decaying) from the production of commodities to be equal to 19% for developed countries,

24% for developing countries. *WW* is therefore equal to $C_{XB,ty}$ multiplied by 0.19 for developed countries and 0.24 for developing countries.

Short-lived fraction (SLF)

Winjum *et al.* 1998 give the following proportions for wood products with short-term (<5 yr) uses after which they are retired and oxidized (applicable internationally):

Sawnwood	0.2
Woodbase panels	0.1
Other industrial roundwood	0.3
Paper and Paperboard	0.4

The methodology makes the assumption that all other classes of wood products, and where wood product class *ty* is unknown, are 100% oxidized within 5 years.

Therefore SLF will be equal to:

$$SLF = \left(C_{XB,ty} - WW\right) * slp \quad (5)$$

Where:

SLF	Fraction of wood products that will be emitted to the atmosphere within 5 years of timber harvest; t C t C^{-1}
$C_{XB,ty}$	Total stock of extracted biomass carbon from within the project boundary by class of wood product *ty*; t C
WW	Wood waste. The fraction immediately emitted through mill inefficiency; t C t C^{-1}
slp	Short-lived proportion - 0.2 for sawnwood, 0.1 for woodbase panels, 0.3 for other industrial roundwood, 0.4 for paper and paperboard and 1 for other; t C t C^{-1}
ty	Wood product class – defined here as sawnwood, wood-based panels, other industrial roundwood, paper and paper board, and other
t	*1, 2, 3 … t* years elapsed since the start of the project activity

Additional oxidized fraction (OF)

Winjum *et al*. 1998 gives annual oxidation fractions for each class of wood products split by forest region (boreal, temperate and tropical). This methodology projects these fractions over 95 years to give the additional proportion that is oxidized between the 5th and 100th years after initial harvest (Table 1):

Table 1: Proportion of remaining wood products oxidized between 5 and 100 years after initial harvest by wood product class and forest region

Wood Product Class	Boreal	Temperate	Tropical
Sawnwood	0.36	0.60	0.84
Woodbase panels	0.60	0.84	0.97
Other industrial roundwood	0.84	0.97	0.99
Paper and paperboard	0.36	0.60	0.99

OF is therefore equal to:

$$OF = \left(\left(C_{XB,ty} - WW\right) - SLF\right) * fo \quad (6)$$

Where:

OF	Fraction of wood products that will be emitted to the atmosphere between 5 and 100 years of timber harvest; t C t C^{-1}
$C_{XB,ty}$	Total stock of extracted biomass carbon from within the project boundary by class of wood product *ty*; t C
WW	Wood waste. The fraction immediately emitted through mill inefficiency; t C t C^{-1}
SLF	Fraction of wood products that will be emitted to the atmosphere within 5 years of timber harvest; t C t C^{-1}
fo	Fraction oxidized – see Table 1 for defaults; t C t C^{-1}
ty	Wood product class – defined here as sawnwood, wood-based panels, other industrial roundwood, paper and paper board, and other
t	*1, 2, 3 … t* years elapsed since the start of the project activity

III. DATA AND PARAMETERS NOT MONITORED (DEFAULT OR POSSIBLY MEASURED ONE TIME)

Data / parameter:	*OF, SLF, WW*
Data unit:	t C t C^{-1}
Used in equations:	4, 5, 6
Description:	OF = Fraction of wood products that will be emitted to the atmosphere between 5 and 100 years after production; SLF = Fraction of wood products that will be emitted to the atmosphere within 5 years of production WW = Fraction of extracted biomass effectively emitted to the atmosphere during production
Source of data:	The source of data is the published paper of Winjum *et al*. 1998[2]
Measurement procedures (if any):	
Any comment:	

Data / parameter:	*CF*
Data unit:	t C t^{-1} d.m.
Used in equations:	3
Description:	Carbon fraction of dry matter
Source of data:	Default value 0.47 t C t^{-1} d.m. can be used, or species specific values from the literature (e.g. IPCC 2006 INV GLs AFOLU Chapter 4 Table 4.3).
Measurement procedures (if any):	
Any comment:	

Data / parameter:	*D*
Data unit:	t d.m. m^{-3}
Used in equations:	3

[2] Winjum, J.K., Brown, S. and Schlamadinger, B. 1998. Forest harvests and wood products: sources and sinks of atmospheric carbon dioxide. *Forest Science* 44: 272-284

Description:	Mean wood density
Source of data:	The source of data shall be chosen with priority from higher to lower preference as follows: (a) National species-specific or group of species-specific (e.g. from National GHG inventory); (b) Species-specific or group of species-specific from neighboring countries with similar conditions. Sometimes (b) may be preferable to (a); (c) Global species-specific or group of species-specific (e.g. IPCC 2006 INV GLs AFOLU Chapter 4 Tables 4.13 and 4.14).
Measurement procedures (if any):	N/A
Any comment:	Wood densities must be validated with either limited destructive sampling or direct measurement of wood hardness (e.g. with a Pilodyn wood tester) and correlating with wood density. Samples or measurements should be from 20-30 trees. For validation of mean species group wood densities, representation of species in the sample should be proportional to their relative composition of harvested volumes. Samples should provide representation across the length of the tree. Wood samples are cut in discs and thickness and diameter measured to calculate green volume. Samples are oven dried (70^{o} C) to a constant weight in the laboratory, and density calculated as dry weight (g) per unit green volume (cm^{3}). If the density of the samples/measurements (or mean density in the case of forest type or species group means) is within ±10% of the selected density values, then the selected density values may be used. Otherwise, a new density value must be developed with more extensive sampling, using the validation samples as a base.

IV. DATA AND PARAMETERS MONITORED

Data / parameter:	V_{ex}
Data unit:	m3
Used in equations:	3
Description:	The volume of timber extracted from within the project boundary (does not include slash left onsite), preferably reported by species and wood product class. Where no direct information on volume by wood product class is available (e.g. illegal logging) it is acceptable practice to assign gross percentages of volume extracted to wood product classes on the basis of local expert knowledge of harvest activities and markets.
Source of data:	Timber harvest records and/or estimates derived from field measurements or remote assessments with aerial photography or satellite imagery.
Measurement procedures (if any):	
Any comment:	Note that this volume does not include logging slash left onsite (tracked as part of the dead wood pool). Data compilers should also make sure that extracted volumes reported are gross volumes removed (i.e. reported volume does not already discount for estimated wood waste, as is often the practice in harvest records)